The Seven Sense
in
Man and Animals

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The Seventh Sense in Man and Animals

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IF a manager had seven bright and faithful messengers fetching him specialty information continuously through passing years, he would be thought strangely stupid if he knew only five of them. But if one was timid and insignificant, and another only appeared when the manager was ill or highly disturbed, his ignorance would be less marked. Five of our special sense organs—those of sight, hearing, smell, taste, and touch—have always been known to us. The sixth, our muscle-pressure sense, had to be dragged from a dim corner by physiologists to be recognized; while the seventh sense, insufficiently named equilibration, seldom makes itself known to consciousness; is, in fact, an automatic sense.

So fundamental is equilibration in animal mechanism, it may even be said to have preceded consciousness in functional evolution. It is our oldest special sense, and the last to receive recognition. Biologically the semicircular canal of the ear, which is our organ of equilibration, was the stem on which was grafted the organ of hearing—the cochlea. The two are anatomical bedfellows, occupying a bone cavern—the labyrinth—like dwellers in a double house using the same vestibule. They are bathed by a fluid that flows freely from one to the other, the limpid lymph which quivers responsive to every vibration of sound playing against the outer drum of the ear. Hence, though we see no occupational relationship between semicircular canal equilibration and cochlear hearing, they must be described together.

No living product of the vegetable kingdom finds use for equilibrial aids, for they are one with Mother Earth, and leave all questions of gravity, motion, and balancing to her. Nor in the animal kingdom do home bodies like the oyster, anchored to one spot for life, find need of such aids. Nature bestows no luxuries, no organs that cannot be serviceably employed. The oyster could do nothing with eyes or ears if it had them. But the day that locomotion is acquired by any creature, a sense organ of equilibration is needed. It is the privilege of the six senses mentioned to keep us informed of our surroundings, to flood the mind at all times with unsifted information of light, sound, scent, form, quality, and weight—of the *outer* world in its bearing on our self-preservation. It is the function of the equilibration sense to inform us of our relations to the outer world—in the absence of all other sense information. I say "inform," but hardly that, because it guides without asking permission, being automatic, and actually performs a magnificent and essential service while ignoring our inflated conscious ego.

There is such an extensive overlap in the service of our special senses that the loss of one may not disable us. And it is a rare situation in which we find ourselves solely dependent upon the equilibrial canals for guidance. If blind, one may still walk naturally over an open plain, fairly well on a sidewalk with a cane, but scarcely at all by stones over a brook. Touch and muscle-pressure in the soles of the feet and body generally aid. But a blind man with locomotor-ataxic loss of sole sensations could not even stand erect, although here his equilibrial sense should carry him through the difficulties. But though sole touch is dead, one can stand and walk if one can see, just as some deaf mutes can learn to speak without hearing their own voices.

Our knowledge of the pull of gravity we accept as a matter of course, so constant is its impress from earliest consciousness. Naturally we have slight

slowly, "and 'twas Jonas Clegg who was gone, and it's Jonas Clegg, when he's found, that 'll stand trial for the murder of one that was like a father to him."

"The monster!" burst forth the old gentleman, when he could get his breath. "I knowed from the start there was something wrong with *him*. Jonas Clegg always looked awful bad to me. You can't never trust a pussy-cat."

His consternation overflowed once more unavailingly from his family group to the trunk of the locust-tree.

"He looks bad to other folks, looking back on him now, Uncle," said his niece. "Like a man that was so fond of money that he'd rob his benefactor to add to the sum he was laying by. Like a man who would put the blame on some one else when the money was missed—and like a man that 'd commit a brutal crime in his terror at being found out, as he was found out when Jedidiah Peeble surprised him at his safe, as he must have done. There's no knowing how much money he took besides, that the old man didn't miss. Most of the sums for mercy and charity went through his fingers."

"The monster!" said the old gentleman again. "I'd like to lay my hands on him for a few minutes. *I'd scrunch him all to pieces.*"

He brandished his arm ferociously. He did not look any more toward the stranger for sympathy in his feelings.

"Uncle Catwood!" said his niece Harriet, "you wouldn't do that! But you'd deliver him over to justice, as we all would if we could lay hands on him—deliver him over to justice as Jedidiah has done with his dying hand."

He did not stop brandishing his arm. "I'd deliver him over to justice, then, and let him get hung of himself!"

"He'll be hung," said his grandson Noah, firmly, "if he don't escape."

"Luretta Skates says the wretched being can't escape," said the little spinster. "They're hunting for him high and low. It's only a question of time."

"He can't escape!" said the old gentleman, with much satisfaction. "They'll get him sure." He sat bolstering himself back into peacefulness with this notion.

Although it was getting late for a family party, with supper on hand, to stay away from its destination, no one made a movement to go on. The crime had cast a spell on the innocent field. It seemed impossible to do anything else than to sit on and on, talking over an evil deed with hushed voices.

Mr. Catwood gradually grew apoplectic again, and would presently have burst forth with an increased violence had not his niece Harriet reluctantly collected together the bundles on her knees.

"Come," she said, "we must not stay any longer, poor Jedidiah Peeble or not. Thomas has been waiting so long I'll warrant he's turned into vinegar."

"I'll warrant!" said the little spinster.

One by one they clambered stiffly from their places in a stir toward leaving.

This time the old gentleman checked the departure, though more briefly than his niece Harriet had done. He pointed suddenly with a child-like forefinger to the sky, where a patch of white clouds floated against the horizon. The others looked whither he pointed. By a curious chance the clouds appeared to form the venerable outlines of an old man's head, crowned by angelic hair. "How queer!" said his niece Susan. Her sickly face was touched with awe. While they looked the clouds assumed a sunset tinge. The beams of the expiring day rested on the pasture and gave to everything swiftly an altered appearance. The locust-tree was illumined. The hedge shone. The sparrows that chirped among the thorns fluttered about momentarily with burnished bodies.

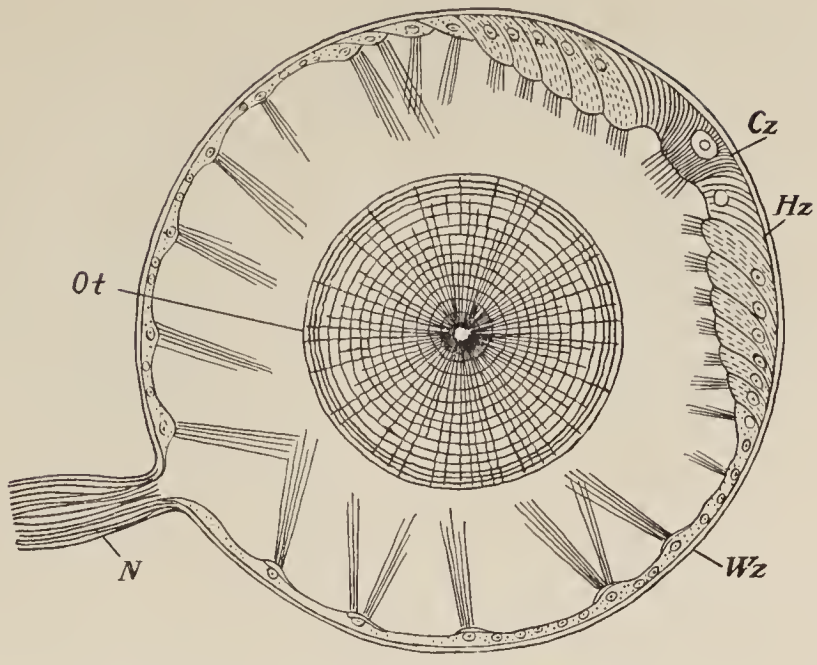
Themselves grown resplendent, the intruders moved away at last, in the midst of the miracle of transfiguration. Until they disappeared through a gate in the distance, the old gentleman's arm struck out, every now and then, stoutly from his shoulder.

Left alone, the man on the stone did not return to his interrupted sleep. He struggled agitatedly to his feet. As he crept off in a timid haste over the stile he stared down at himself with a terrified aspect. He, too, had received a color from the sky. There was red on the hand lacking one finger which grasped his neat bag; there was red on his precise coat and vest, and there was even the semblance of a crimson stain on his prim, old-maidish shoes.

opportunity to get acquainted with our internal gravity-finders. Let us assume a situation of sole reliance upon our semicircular canals for guidance. To find such a situation we must take on the anatomical habiliments of a fish—while retaining our human intelligence. We are submerged in water; there is no glimmer of light; there is no movement in the water, and we are of the same specific gravity as the water, with no tendency to sink or rise. It is just as easy to swim in one direction as another. Now which way lies the center of the earth, and which way leads back to terra firma? We each have some 200,000 touch sentinels distributed in the cuticle, and every one is lapped by briny water; but all are telephoning the identical message, "briny waters." No organ, not even the semicircular canals, can sense our earth's axial motion, nor its eighteen-thousand-miles-per-second orbital flight. A man in a submerged submarine will possess a half-dozen direction sign-posts. But we will have possibly one—the semicircular canals; or two—our internal gravity of blood if we lie head downward; or three—the weight of a full stomach when facing the stars. But if we must quickly get back to air to breathe, not one of these will serve in the panic that would come upon us. A fish in such condition is a composed creature gently sustaining perpendicularity with waving fins. Yet our equilibrial organs appear far superior evolutionally to the simple sacs found in fishes. So we must have been making greater use of them, or they would have joined the "has been" ranks with appendices.

Now if we, as conscious egos, alert to all bodily sensations, find we cannot physically conduct ourselves naturally without normal service of the semicircular canal structures, and cannot get them to work through our conscious minds, how may we discover what they do and how they do it?

The temporal bone of the skull, which extends underneath the brain in its middle portion, is hollowed to form a Lilliputian cavern, a cast of which forms the labyrinth, or inner ear. In it lie the sensing structures of hearing and equilibration. If it were many times larger than it is, it would still be the most complex and puzzling structure ever created. As it is, there are many diamonds large enough to contain it.



A primary form of the organ of equilibrium, found in the heteropod mollusk. (After Claus.) *N*, the nerve (called auditory nerve, but is an equilibrial nerve in primary form). *Ot*, an otolith, or ear-stone, floating in fluid; *Wz*, sensory hair-cells; *Hz* and *Cz*, other forms of sensory hair-cells

Let us, therefore, move down the Nature scale to her simplest toy beginnings, and consider jellyfish and prawns. First forms of sense organs are very simple indeed. The first form of inner ear-labyrinths is a simple sac opening freely to the water. Its chief function is equilibration, and so far as it acts in hearing, it only senses the incidental by-product of sounds — wave quiverings.

If an inventor were asked to design a gravity-compass that would not infringe on the pendulum or magnetic compass, he might suggest a hollow sphere, filled with fluid, having many pins just piercing the shell, all pointing to the center; and a small ball slightly heavier than water lying in the fluid; the outer heads of the pins to be wired through a battery cell to an annunciator, so that when the ball settled to rest on several pin-points, a current would be established which would show on the dial of the annunciator the place where the ball lay, and therefore just what is the undermost part of the sphere. Substitute a chalky pebble for the ball, sensory cells with fine hairs floating in the fluid for the pins, nerves for wires, a nerve ganglion for the battery cell, and more or less conscious ego for the annunciator, and we find an infringement

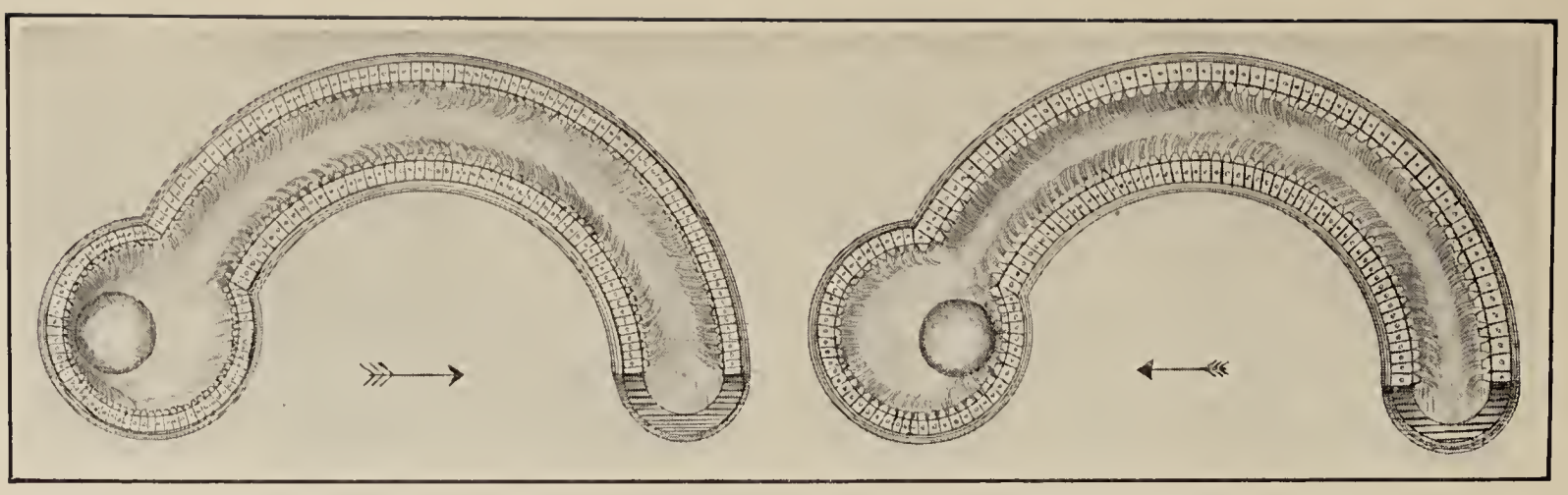


DIAGRAM ILLUSTRATING THE MODE OF ACTION OF THE SEMICIRCULAR CANALS

In the left canal the body is advancing, the inclosed fluid presses backward, through inertia, which bends the cell hairs (cilia) backward (to the left in the cut); the ball (otolith) also presses backward. In the canal to the right the body is moving to the left (backward). On coming to a halt the ball settles to the lowest part. The arrows show the direction of the movement

of Nature's primary equilibrial sac. While the jellyfish buds from the stalk of a sea-inlet water plant, it has no more use for equilibrators, as it bends to and fro in the diurnal tides, than the oyster on a rock. But when it loosens its parasitic hold and starts on its destined journey to fatten some fish's maw, it finds some need of internal gravity-finders; though, as its protoplasmic propeller cannot steer, nor hold its own against the tide, and its streaming equilibrators, being heavier than its bell-shaped head when moving, force it ever upward while drifting with the tide, it probably gets a moderate service from its internal equilibrial sacs, as does the worm with its pigment-spot eyes.

Equilibrator sacs in some forms of aquatic creatures are an extension of the skin. These sacs are lined with cells which have a number of delicate hairs projecting from their free ends into the fluid which fills the sac. These cells, like the rods and cones of the retina, are specialists, and can sense the variations of pressure of the sac fluid, more delicately because of the floating hairs; and also feel the weight of small pebbles which lie in the fluid. These pebbles in the open-sac forms are picked up from the sea bottom and poked into the sacs after shedding; or, in closed-sac form, are chalky substance there manufactured. They are called otoliths — ear-stones. Starting in the nuclear protoplasm of the sensory cells, nerve filaments run outside the sacs as nerve cables to the brain, and there announce their sensations. Many able men had observed these sacs, hair-cells, and pebbles; but while the function of equilibration was largely unknown the explanation was difficult. The nerve cable led to the brain region, where in higher creatures hearing lies. "Something to do with hearing." A natural guess, yet misleading. To destroy these sacs in life may indicate their use through consequent observable loss of function. But to control their action while whole and sound would be a triumph.

Kreidl observed that the palæmon—the common prawn—shed its sacs. When the new sacs form, the prawn gathers selected pebbles (much as a fowl will stock its gizzard with chicken mill-stones), and pokes them into its "ears." Kreidl removed all sand from water, in which he placed a disrobing prawn, and put iron filings in their place, which the prawn proceeded to use. With a magnet the iron "otoliths" could now be made independent of gravity, and brought against any portion of the sac walls. The prawn was not drawn this way and that, as the toy fish of our childhood followed the magnet, but rolled like a water-logged derelict, a misled victim of magnetized iron. This turning the prawn's world topsy-turvy, making a magnet its earth-center and upsetting its gravity, from the investigator's point of view was a brilliant and useful application of physics. Could this test be applied to man, passes with the magnet might not make him roll about, but would render him deathly seasick, and the world would seem to whirl.

In the production of music, the one

object is to make tonal sound, and yet there must be an incidental by-product in the atmospheric vibrations that make the sonorous sound. Air has weight, and its vibratory waves carry momentum and weight—make material impress. A horn played before a candle-flame causes it to quiver rhythmically—this is the vibratory cause of music made visible. If the candle and flaming wick represented a sensory cell and hair, such as those lining the equilibrial sacs, it could sense this atmospheric vibratory impact as motion, but not as sound; and to this extent do fishes probably hear. This is not true audition, but a modified form of touch performed by equilibration cells. In air-borne vibrations, sound is far more potential than air-wave impact, and it is not possible for our equilibrial sensory cells to feel the latter; but in water, which is over eight hundred times heavier than air, the physical impact of sound-waves is easily sensed. In one second, sound-waves travel through air at freezing temperature 1,090 feet, through shallow water 4,708 feet, and through iron 16,000 feet. Momentum and intensity are enhanced by speed and weight. The janitor who grudgingly feeds the hungry furnace with coal cares nothing for the salicylic acid, creosote, carbolic acid, and dozens of headache cures going to combustion; and conversely the fish cares nothing for the main product of vibratory waves — music. If a fish possessed our hearing organs, a submarine orchestral performance would be as a cataclysm of the spheres. Water noises mean to a fish the presence of schoolmates—friends or a foe—an invitation to dinner, or breakers ahead; and they have strange little telephones or ear-drum resemblances distributed in the skin of head and trunk, in addition to equilibrial sacs, which vibrate—not sound—the alarm. But their great locomotive need is equilibrial organs.

The equilibrial organs are believed to sense wholly by internal means, and without assistance of other senses, the direction of gravity; of motion, its direction, speed, cessation; to sustain tone or tension in such muscles as keep the body, when awake, in equilibrial balance; and assist the cerebellum in working many combinations of muscles co-ordinately — harmoniously — to perform given acts.

Why does a dying fish turn belly up? Not because of bloating—a post-mortem cause — but through loss of muscular tonicity and the constant co-ordinate waving of fins that held it perpendicular. The moment a man arises from bed he automatically sets many muscles into a moderate and varyingly adjusted degree of contraction to keep his jointed vertebræ and lower limbs from flexion. If he sits erect and motionless, these sustaining muscles are as set and immobile as if they were coil-springs or rubber bands. If he slightly changes position, a nicely balanced readjustment of all these muscles is made, and the originating impulse to adjustment springs from his semicircular canals. This is equilibrial adjustment, but there is a preliminary stage we might term getting-ready-to-act — simple tonicity, muscle-awakeness. He will sustain both these states of tonicity and equilibrial tension until he lies down—ending the latter, and goes to sleep—ending the former. In over-tired condition he may be unable to end tonicity through irritability of the combined nerve structures, which

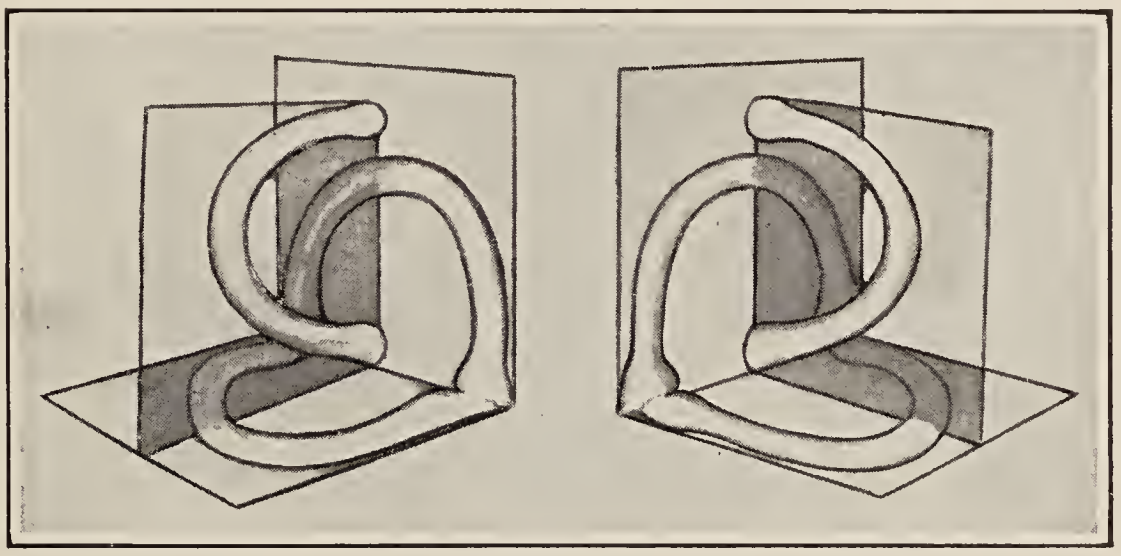


Diagram to show the position of the planes of directions of the semicircular canals in the head, looking forward, with head erect

is similar to after-image action of the retinas from too strong a light. We see the working of this machinery, the turning on and off of the nerve current, when a man riding a horse gets just so far in sleep as to start falling, or when one listens to a droning sermon or overdetailed yarn, nods and then quickly recovers himself. Consciousness has little to do with this breaking of the tonicity current. There is an extended grade between fullest awake and deepest sleep states, but the nod marks the exact division-line between the two.

Muscular tension gives us motionless equilibrium, but must be assisted by muscular co-ordination in such feats as tight-wire balancing. Threading a needle is a simple act in normal co-ordinate states, but impossible by an intoxicated man. Threading a needle involves fixation of spine, head, and eyes, and delicate co-ordinate handling of arms and fingers —hundreds of adjustments. A railway station-master inserts a perforated card at the bottom of a train bulletin, turns over a lever, and every station to be touched by the departing train is named on the shutter slats. This is cast-iron co-ordination, a fixed combination. But hitch a hundred wild steeds abreast with single harness to a chariot, and find a jehu able with his two hundred reins to drive them co-ordinately. This, if it could be done, would outrival the performances of our muscle-drivers only because wild steeds do not wait to be driven, and muscles do. We get a beautiful picture of multiple harmonious co-ordinate action in an eight-oared race. But there is conscious brain regulating each oar; so, to find a perfect example, we pick a hurrying centipede. How beautiful is his automatic co-ordination! Provide him suddenly in his flight with self-conscious control, and he might get badly tangled legs and feet.

The cerebellum adjusts the degree of each muscle's contraction to secure co-ordinate work, but it is not a thinking brain, rather a vast collection of nerve batteries which only act on muscles when excited by various stimuli. The equilibrial sense organs supply many of these, and the will can do the same without including the equilibrial organs, but the direct call upon the muscles in either case must proceed from the cerebellum.

Theoretically, if a fish, lying still, swims forward, inertia of the fluid filling the equilibrial sacs will cause this fluid to press backward—more or less, according to speed—and bend the floating hairs of the sensory cells backward. If the fish continues swimming, this fluid inertia will be soon largely overcome, allowing the floating hairs to straighten. Movement away from a straight line should cause pressure by the fluid against the opposite sides. On stopping, momentum of the fluid should cause pressure forward. Coming to a complete halt, the otolith should settle upon the most dependent sensory cells and hairs.

Every item of flexion of the hairs and pressure on the cells should make impress on the nerves imbedded in these cells; and they in turn, sending each an individual impression to the brain, the combined sensations stimulate the cerebellum to proper action.

Equilibrial sacs which are open to the sea-water are simple and crude. We find the equilibrial sacs closed in higher-scaled creatures; the otoliths are not the simple round pebbles here mentioned, nor floating free, and our theory of their service may need changing. They are often of the shape of crystals, may be imbedded, and may serve in some way to intensify vibrational effects. While the destiny of the vast majority of lowly creatures is to enter, more or less alive, some stronger creature's stomach, and while equilibrial organs are necessary to them, they will never move so far out of stable conditions as to meet disaster from equilibrial incapacity. But the bird, the deep-diving or high-flying man, stake their lives on equilibrial reliability.

If our theory of the creation of sensations in the equilibrial sacs through varying pressures and vibrations of their inclosed fluids is correct, then it seems reasonable that tubular sacs would give stronger current impressions than spherical sacs. The semicircular canals in the labyrinth composing the internal ear in man are essentially the original spherical sacs, with half-circle tubular extensions. The otoliths are found in the primary bulbous parts of the canals, and the tubular parts are lined with sensory

hair-cells. Further, the fact that the three canals of each ear-set lie, one horizontal and the other two perpendicular, and at right angles to each other, thus meeting all possible dimensions of space, compels the belief and seems to confirm the theory that sensations of position and motion are the product of fluid action through inertia, flow, and momentum. Still further, fluidic fluency is secured through the canals being directly and patulously connected with the cochlea, and by outer tubular linking of one part with another, all somewhat like a hot-water heating system of circulation, without the heat.

If one stands erect and turns the nose to the right, the inertia tendency of the fluid in the horizontal tube of the right ear will be forward, and in that of the left ear backward. Therefore the brain will receive rotary motion sensations derived from opposite currents in the two ears, advance in one and retreat in the other, or apparently flat contradictions. This is also true of the perpendicular tubes. But from first movements of a baby's head the sensory hairs have thus bent in opposite directions, and it was not through recording whether the two ears testified alike, but what was the combined effect following a given movement, that the growing brain learned to interpret.

It is the fundamental function of sense organs to specialize in receiving sensations, each from some particular phenomenon of materials and forces about us—with the exception of the equilibrial sense; and to deliver these sensations to a conscious brain, which in turn can employ some judgment in making use of their information regarding the outer world.

It is very dark in the brain, and the brain has no conceptions of its own—except in abstruse cogitation; and most of its conceptions are derived from and shaped upon the particular knowledge gained from its sense messengers. We think of events through their qualities—lights, colors, sounds, scents, etc.

Now the equilibrial organs inform us, in distinction from all the other senses, not of the outside world's relations to us, but of our relations to the outside world. And they are automatic. This automatism of the equilibrial sense has made it doubly difficult to determine the functions of the semicircular canals. The pancreas is wholly automatic, but its secretions for starch digestion can be obtained pure and chemically analyzed. But no machine has ever been invented that can weigh or analyze a sensation, even less sensations which seldom reach consciousness.

Some of the secrets of the semicircular canals can be forced into the open by destroying them and observing the effects. Injury to one of the three canals in one ear will cause exaggerated movements of the head in the plane of that canal. Thus, if the horizontal canal in a pigeon be injured, the bird will swing its head to right and left in unusual degrees; and after injury to one of the perpendicular canals, will turn somersaults forward or backward. It will not try to fly, and if thrown into the air will lose steering control and flop to the ground. Severance of the nerve connecting the canals with the cerebellum in a dogfish causes it to stop swimming and lie like a listed ship to starboard or port, or to turn turtle. The dogfish might be able with its eyes to see that it is lying out of plumb, but would not try to trim boat. It could not succeed.

Every sense organ can be worked into a state of irritation. The eye sees after-image suns sometime after sun-gazing; the ear hears the roar of a cannon after the air has ceased vibrating. This is not ear-drum reverberation, but postphone scolding by the sensory hair-cell's nerve terminals. Every child discovers that a dervish whirl will cause dizziness and collapse, and thinks it fun to play tag with its abused semicircular canals. The deaf, whose equilibrial organs were consumed with those of hearing in the flame of meningitis or scarlet fever, may whirl and not grow dizzy. Dead cells cannot scold. Neither are such equilibrially deaf prone to grow dizzy on heights, nor when hit on the head. Nor, in the dark, can they stand on one leg, nor on two on an inclined plane, nor keep on a narrow plank path in walking.

Balis, who became deaf through meningitis after learning speech, and who was probably injured in the left semicircular canals only, states: "Locomotion in the twilight demands the whole available

right of way, unless I have a fixed point to guide me. At night I must have a light-guiding point or be able to touch something. In passing persons and things on my left, it is often impossible to avoid collisions, though to pass on my right there is no difficulty. I cannot walk straight with one eye closed, or swim without going under on the blind side. I go under on either side when I attempt to swim in the dark." The story of the thirty deaf who "owned the ship" and never missed a meal, while ear-sound fellows groaned through a three days' storm, is cheerily preserved in the records. The deaf are peculiarly liable to drown if their semicircular canals are destroyed, from bewildering loss of direction sense. Gallaudet College for the deaf supplies a "they-say" tale of a deaf boy diving into a ten-foot tank, who mistook a patch of sunshine at the bottom for surface light, and vainly floundered, through lost-direction sense, until, half drowned, his unconscious body floated to rescue by his fellows. Who needs to be told of the effects of a rolling ship? If no sailor, you may stand or sit or take to your berth —there is a canal for every angle, and one of them will fit your case until the equilibrial batteries are exhausted and no longer able to harass the innocent pneumogastric nerve and stomach. Jumping foot first from haymow or diving-platform excites a sinking feeling in the stomach region—excited by the canals. The dizziness from continued whirling in one direction is due to abnormal excitation of the horizontal canal's nerves.

The "reverse" in waltzing was not instituted arbitrarily by dancing-masters, but through the compulsion of physiologic law. The appearance of everything in a railway car moving rearward when one turns the eyes from continued retinally exhausting observation of the moving car-window panorama, is a form of after-image irritation in the eyes, accentuated by the semicircular canals. Apparently we can secure sensations from the semicircular canals only in abnormal excitations; and this is characteristic of all automatic bodily machinery. If one knows that he has a stomach, then it is out of order. Pain is the annunciator of automatism in all organs except the fundamental "seventh" sense. Its annunciation is literally and biologically through "upsetting one's gravity," and strikes through the veriest fundamentals —heart, brain, and stomach.

How can one receive aid from a sense organ, be unable to do without it, be guided by it, and yet receive no conscious impress of its existence? Consciousness is the one surpassing possession of life. But out of the hundreds of thousands of bodily acts daily occurring in our lives, not only are the vast majority done independent of consciousness, but many of them are as liable to be hindered as helped by its supervision. Specialized organs: pancreas, liver, spleen, thyroid, thymus, adrenals, *and semicircular canals,* guide through such simple (?) and vulgarly material means as stimulation, excitation, reflexion, and other forms of nerve and nutrient action, the intricate needs of a complex physiology. We sense the hunger of the stomach, because we must, in our expanded sphere, find its food and administer it. But we do not sense the hunger of the blood for more thyroid or adrenal secretion, because they can give for the asking, and the voice that calls is a chemical whip, so to phrase it. Magnificent automatism! So far as we know, the only difference in the automatism of the equilibrial sense and that of liver and other structures is, that the semicircular canal structure is acted upon, excited to action, by vibrations and gravity instead of chemical or electrical stimuli. In summation: we find in practically all feats of equilibration that the fundamental non-conscious sense is assisted by the conscious senses sight, touch, and muscular pressure; and that we casually award all the credit to the latter three senses. They are the steering-gear of the ship, but the canals are the ballast in the hold.

We are all familiar with the sensations of breezes blowing through our locks—the thinner the hair the keener the sense. An insect's antennæ can outrival a brace of mule's ears in delicate detection of the direction of sound, through its relative impress on the nearer and farther antennæ. There are no nerves in hairs or antennæ, but their roots are well supplied, and sense every bend and quiver of these structures. Of such character

are the sensory cell tubes which compose the working parts of the semicircular canals that lie within the larger calibered bony tubes, which, though attached by bands to the bone walls, really float in fluid that also courses inside: The hair-cells lining these inner tubes will all quiver when the fluid quivers, only the free-end hairs will respond to more delicate fluid vibrations and currents. The nerves leading from these parts will carry nerve wave-vibrations that are exact duplicates of the fluid's, and transmit them to brain-receiving cells. The semicircular canals in higher animals, in addition to gravity and motion-direction sensations applied to them, must receive the same sound vibrations that are sent to the hearing apparatus, and we must presume that sound vibrations have some part in semicircular canal sensations; but what they are is not determined.

Human aviation makes an appeal to the semicircular canals that they have never had before. In so far as aeroplane equilibrium is not secured through the machine, is not mechanically automatic, it must depend upon the aviator's sight, touch, muscle-pressure, and semicircular-canal senses; and to that extent man must bring the sensitiveness of these parts to the standard of the bird. The bird depends wholly upon sight and semicircular-canal senses in flying. Possibly some animals can outrival man in every sense, certainly in scent, and probably in sole use of the equilibrial sense organs. But man undoubtedly possesses the highest average of all animals. He has evolutionally passed through every grade of excellence achieved by any animal with any sense. But lessened demand on one sense through increased service of others must cause some deterioration in the unused sense. Has the service of our semicircular canals retrograded? It is just possible for man to place himself in a position of sole reliance upon his equilibrial sense — in dark, briny water, while the fish is so dependent every night. In a bird the equilibrial sense must act far more quickly than in the fish. The bird gets aid from its eyes, which change focus more quickly than man's eyes. We know that our equilibrial sense is slow compared with its chief assistants, sight and touch. Our equilibrial sense does not ordinarily reach consciousness, except in severe conditions. Did it at one time, and have the nerves of connection simply weakened through disuse?

Do flying birds receive conscious sensations from the equilibrial organs? If they do not, then that much is evidently not necessary. If they do, can we acquire or regain such function? Loss of one sense greatly enhances the capacities of the others through continued concentration, and devotion to special occupations will add much to skill in a special sense organ. Man's equilibrial organs are now equal to ordinary demands in aviation, such as clear-air, low-level flying in straight spiral or double curve planes, acquired familiarity through practice being the main need. But place him aloft in a fog, with touch and pressure senses benumbed with cold, with the machine supported by the elastic cushion of the open air, he then has three aids to equilibrial knowledge: his natural equilibrial sense, a dulled pressure sense, and sight knowledge of his lifting planes. He will not in such situation consciously rely upon his equilibrial organs, but upon the visible positions of his lifting planes and what he can feel of the machine under him. The latter will not inform him of slight deviations from the horizontal in any case, especially encased in heavy clothes and cold. Blindfolded, he could gauge his variation from the horizontal only by the positions of the lifting-plane levers in his hands, and could probably not bring himself safely to earth. He will consciously sense his equilibrial or semicircular canal impressions if descending rapidly—the falling sense. Should he descend rapidly from these near two-mile heights, he may suffer faintness from over-sudden change of air density—a form of "caisson" disease.

The intellectual or reasoning superiority of man over birds is liable at any time to impose a danger not liable for the bird—fear through knowledge of his risk, and consequent loss of self-control—of co-ordination through shock. This will surely claim its victims, if it has not already, unless automatic equilibrium in the machine can be attained and relied upon in such emergency. At nearly ten thousand feet from the earth an aviator

stated that "he lost to a considerable extent his sense of the horizontal," and the earth looked like a concave saucer. This was in clear air, but the lateral boundaries on which his eyes were accustomed to rely for sense of perpendicularity were so far removed that they lost impress. Assuming consciousness in space beyond the earth's atmosphere, only two sense-organ functions could perform: semicircular-canal sense of motion (perhaps), and sight of the sun, earth, and moon. In addition to benumbing from cold, touch and pressure sensations are weakened in great altitudes by lessened gravity.

About every thirty days new squabs appear in the pigeon-loft. And in another thirty days or so every one of them can perform one of the most puzzling tricks known in physiology. These pudgy squabs can be carried encaged in darkness many hundred miles, loosened in air, and can fly straight back to the loft they know as home. All the homing pigeons can perform this wonder, and without any eye-memories to aid. Call it instinct, and you make no more progress than does an automobile running with its wheels jacked up. Sense memory is not an intellectual capacity, and is often greatest in minds markedly deficient in intellect. Such was Blind Tom, and such was an idiotic negro known to the writer, who could state in a few seconds how many times a cart-wheel would revolve going to town, or Jericho, and back. Such brains suggest an arid desert, soiled and fertilized in spots. Animal memories are lasting. The dog knows for weeks where he buried a bone or routed a rabbit. Interstate birds of passage annually return from distant winter visits to last year's nests.

If our conceptions of the functions of the semicircular canals are correct—that every start, direction in motion, and stop of living bodies excites an impression independent of all other impressions—we can at least suggest that the line of service of the semicircular canals is the nearest of any known function to explaining the homing performance—even though this seems next to impossible. We know that it is not an unsolvable puzzle before us; some physiologic resource must meet the problem. But apparently we must hold that the semicircular-canal impressions in the pigeon are as definite in conscious recognition as are eye impressions in us. Then we must grant the bird a marvelous memory of direction impressions, and even overload the marvelous by considering that the bird may be carried in a car backward, or move into all points of the compass. Perhaps the act is vastly simple, and the bird is guided only by a very general sense of direction until it crosses known territory and converges to home; or perhaps there are magnetic and aerial currents and position of the sun to guide. Whatever the solution, it is not supernatural—that vulgar alternative of ignorance.

The Overflow

BY EDITH M. THOMAS

THE flood-tide sets into the stream,
That then fills up its grassy banks;
But never does the rivulet dream
How to the sea it oweth thanks!

My little loves are fed, each one,
By a great Love they cannot know:
Upbrimmed, they ripple in the sun—
They have my full heart's overflow.

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